

This study is aimed at ascertaining the economic cost of lethal yellowing disease (LYD) on coconut (*Cocos nucifera*) yield in LYD endemic zone in Nigeria. Secondary data spanning over 10 years, 2000 to 2010 was used for this study. The secondary data was obtained from the records of Plant Breeding Division, Nigerian Institute for Oil Palm Research (NIFOR) Benin City, Edo State. The data were estimated using econometric methods such as regression. The software used for analysis was EViews 7. Results obtained from the regression of the data indicate that expected annual yield of diseased palms and price per unit nut are significant determinants of economic cost of coconut production in the area and that LYD is a major threat to coconut production. It is recommended that campaign on how to prevent and control the incidence of LYD should be conducted regularly by extension workers.

INTRODUCTION

Coconut palm, *Cocos nucifera*, otherwise known as the ‘Tree of Life’ because of its versatility as seen in its many uses, is a valuable domestic and export commodity. It is a member of the family

30 ~~Areaceae~~ (palm family). The term coconut can refer to the entire coconut palm. It is derived from
 31 the word **coco** in Portuguese and Spanish, meaning “head” or “skull”, from the three indentations on
 32 the coconut shell that resemble the facial features of a pair of eyes and the nose. It is successfully
 33 grown in the tropic and sub-tropic areas, hence referred to as ‘King of the Tropical Palms’. There are
 34 different coconut varieties and they are divided into two major groups, the ‘Tall and Dwarf’
 35 cultivars. Both cultivars can hybridize to produce intermediate forms [2]. Coconut varieties include
 36 the West African tall, dwarf green, Malayan dwarf yellow, Malayan dwarf red and hybrid coconut.
 37 They are named after areas where they have been grown long enough to have developed distinctive
 38 characteristics associated with these areas of the world [10]. The tall cultivars are grown for
 39 commercial purposes because they have ~~longer~~ lifespan and produce more coconut meat (by weight)
 40 than the dwarf cultivars.

41 Every part of the coconut palm, from the roots to the crown of leaves, is useful and many value
 42 added products are derived from them. The nut or meat is a source of food, provides a nutritious
 43 supplement for body fluids and minerals, mainly potassium and its roots act as ~~anthelmintics~~. The
 44 liquid endosperm is also a medium for ~~in-vitro~~ storage of semen and it is a growth regulator of plants
 45 [10]. Copra, the dehydrated meal or endosperm of the nut is a source of ~~oil for food~~. Coconut oil is
 46 also used in premium cosmetics and pharmaceutical industries. The material that remains after the oil
 47 is extracted from copra is called coconut cake or meal and is used as ~~an~~ animal feed. Coconut shell is
 48 used directly as fuel, filler, and extender in the synthesis of plastics and produces activated charcoal,
 49 household articles and various distillation products such as tar, wood-spirit and pitch. Coir, a coarse
 50 fibre from the husk of the nut has various domestic and industrial uses. Coconut root is brewed and
 51 used in folk medicine, for example, as a cure for dysentery. Agro-forestry uses of coconut palm
 52 include coastal stabilization and windbreaks. It also contributes to aesthetic landscapes, home
 53 beautification for both tourists and locals; and provides employment and income for coconut farmers.
 54 The economies of several nations, e.g. Vanuatu are mainly dependent on their coconut industries.
 55 However, there has been a decline in productivity of coconut ~~owing to~~ a combination of biological,
 56 social and economic constraints. Of these, lethal yellowing disease (LYD) is the most serious

57 because of the direct damage it inflicts on plantings and also the uncertainty and loss of confidence
58 in investment in replanting and rejuvenation of the large populations of older palms [5]. Indeed, in
59 recent years, coconut cultivation has encountered a strong phytopathological constraint generated by
60 the ~~lethal yellowing disease~~ [3].

61 The problem of ~~lethal yellowing disease~~ dates back to over a century in the Caribbean. The
62 devastating epidemic outbreak of ~~lethal yellowing disease~~ in the Caribbean occurred after the Second
63 World War. It has spread all over the Caribbean region, including Cuba, the Bahamas, Haiti, the
64 Dominican Republic, Mexico, Florida, and Texas [7]. It was discovered in Cayman Island in 1834
65 and fifty years later, it occurred in the Western end of Jamaica [7].

66 ~~Lethal yellowing disease~~ also extended to the African continent. The first reliable reference to
67 this disease in Tanzania was in 1905. A few early outbreaks were reported in the first two decades
68 of the 20th century in the Kisarawe, Rufiji and Kilwa districts. Lasting outbreaks were not reported
69 before the 1940s when the modest early groves had been greatly expanded. It occurs in almost
70 the entire coastal coconut belt of mainland Tanzania but tends to be absent or less active in groves
71 further inland [9]. Since 1988 it has also been observed on the Island of Mafia near the Tanzanian
72 coast. In Mexico, in 1982, the first affected coconut palms were observed in Cancun and Isla
73 Mujeres, from where it spread along the coast to Yucatan, Chizen Itza and Telchac. The first cases
74 have also been observed in the city of Merida country. It has been estimated that the disease spreads
75 at a velocity of 50km per year which may have enormous economic consequences for the country
76 [5].

77 ~~Lethal yellowing disease spreads~~ also to Nigeria and other West African countries decimating
78 coconut plantations. The incidence of LYD has significantly reduced the number of coconut palms
79 in the country. Thus, it poses a threat to smallholders' income and the future of the palm-
80 dependents local industry.

81 The coconut palm and its fruit are regarded as the most important plant to humans around the world
82 [2]. Coconut plays an important role in households all over the tropical world from time immemorial

though it remains predominantly a smallholder's crop. The destructive nature of LYD on this multi-purpose palm is, therefore, of great concern to coconut farmers. Its potential to eradicate the coconut palms threatens the economy of affected area [6]. Hence the need to ascertain the economic cost of the impact of LYD on coconut yields in the ~~disease-endemic~~ zones of Nigeria. To the best of our knowledge, it was observed that there is an information gap in this area especially in the Nigerian agricultural sector. This research intends to bridge that gap by evaluating the economic cost of the ~~Lethal Yellowing Disease~~ on coconut yield in ~~LYD-endemic~~ areas of the country. Consequently, we aim to contribute to the body of knowledge in this area of study.

The Objectives of the Study

The general objective of this study is to: ascertain the economic cost of LYD on coconut yield in ~~LYD-endemic~~ zone of Nigeria.

The specific objectives of the study include the following:

- I. To assess the effect of LYD on coconut yield
- II. To determine the ~~economic cost implication~~ of LYD on coconut production
- III. To proffer appropriate preventive/control measures against LYD to coconut farmers

Research Hypotheses

The hypotheses of the study are as follows:

Hypothesis 1:

Null Hypothesis (H_{01}): ~~Lethal yellowing disease~~ has no significant effect on coconut yield

Alternative Hypothesis (H_{11}): ~~Lethal yellowing disease~~ has significant effect on coconut yield

Hypothesis 2:

104 Null Hypothesis (H_{02}): ~~Lethal yellowing disease~~ brings no significant economic cost to coconut
105 growers.

106 Alternative Hypothesis (H_{12}): ~~Lethal yellowing disease~~ brings significant economic cost to coconut
107 growers.

108 **METHODOLOGY**

109 **Study Area**

110 The study ~~is~~ carried out at the Nigerian Institute for Oil Palm Research (NIFOR) Main Station, Km
111 7, Benin-Akure Road, near Benin City, on a campus of 1735 ha. The institute, a research centre
112 established in 1939, has enormous infrastructure developed over a period of about 75 years,
113 comprising laboratories, office buildings, engineering workshops, library, oil mills, over three
114 hundred units of residential houses and municipal services such as water supply scheme, electricity
115 power generators, medical facilities and primary schools. The Institute's human resource consists of
116 research scientists, laboratory and field technical support staff, administrative and accounting staff,
117 library staff, health care workers, clerical and field labour. Currently, the Institute has staff strength
118 of 1,704.

119 ~~The mandate of the Institute is to conduct research on the genetic improvement, production and~~
120 ~~processing of oil palm, coconut, raphia, date, and other palms of economic importance and shea tree~~
121 ~~and transfer its research findings to farmers.~~ Research on coconut started in 1963 and a Coconut
122 Research Substation was established in the main coconut growing area at Abia near Badagry, Lagos
123 State in 1978. ~~The Institute has made considerable impact over the years since its inception through~~
124 ~~research, development and extension support for the Nigerian palms industry.~~

125 **Study Design**

126 The study design employed is record review of the degree of prevalence of various coconut varieties
127 to LYD in Nigeria.

128 **Study Population**

129 ~~The population of this study consists of the existing coconut trees of four varieties (West African~~
 130 ~~Tall, WAT, Green Dwarf, GD, Malayan Orange Dwarf, MOD and Malayan Yellow Dwarf, MYD).~~

131 **Duration of Study**

132 The study reviews coconut production in the ~~lethal yellowing disease (LYD) endemic~~ zone (NIFOR)
 133 for a time period of 2000 – 2010.

134 **Data Collection**

135 The secondary data was obtained from the records of Plant Breeding Division, Nigerian Institute for
 136 Oil Palm Research (NIFOR), Benin City, Edo State.

137 **Data Analysis**

138 Collected sample data ~~is~~ analyzed using Eviews 7 and Ordinary Least Squares (OLS) methods.

139 **The Model Specification**

140 Economic cost is hypothesized to depend on Expected Annual Yield of Diseased Palms (EAYDP),
 141 Price per Unit Nut (PUN) and the Ratio of Diseased Palms to Total Number of Palms (RDPTNP).

142 In mathematical form the hypothesized relationship may be written as follows:

$$143 \quad EC=f(EAYDP, PUN, RDPTNP) \quad - \quad - \quad - \quad (1)$$

144 Where

145 EC = Economic cost

146 EAYDP = Expected Annual Yield of Diseased Palms

147 PUN = Price per Unit Nut

148 RDPTNP = Ratio of Diseased Palms to Total Number of Palms

149 **Model 1.1: Economic Cost (EC)**

150 In econometric form, the model can be expressed as follows:

$$151 \quad EC_t = \alpha_0 + \alpha_1 EAYDP_t + \alpha_2 PUN_t + \alpha_3 RDPTNP_t + U_{1t} \quad - \quad - \quad (2)$$

152 Where

153 EAYDP, PUN and RDPTNP are the independent variables already defined for different time period t

154 α_0 is the intercept

155 α_1 , α_2 and α_3 are the structural coefficients to be estimated; and

156 U_{1t} is stochastic error term

157 From *a priori* expectation or consideration

$$158 \quad \alpha_1, \alpha_2 \text{ and } \alpha_3 > 0,$$

159 Since increase in any of the explanatory variables (EAYDP, PUN, RDPTNP) would increase

160 economic cost of coconut production.

161 Equation (2) is estimated for the four different coconut varieties which include: ~~West African Tall~~

162 ~~(WAT), Green Dwarf (GD), Malayan Orange Dwarf (MOD), and Malayan Yellow Dwarf (MYD).~~

163 Actual output is hypothesized to depend on Total Number of Palms (TNP), Number of Diseased

164 Palms (NDP) and Price per Unit Nut (PUN)

165 In Mathematical form the hypothesized relationship may be written as follows:

$$166 \quad AO = f(TNP, NDP, PUN) \quad - \quad - \quad - \quad (3)$$

167 Where

168 AO = Actual output

169 TNP = Total Number of Palms

170 NDP = Number of Diseased Palms

171 PUN = Price per Unit Nut

172 **Model1.2: Actual Output (AO)**

173 In econometric form, the model can be expressed as follows:

$$174 \quad AO_t = \beta_0 + \beta_1 TNP_t + \beta_2 NDP_t + \beta_3 PUN_t + U_{2t} \quad - \quad - \quad - \quad (4)$$

175 Where

176 TNP, NDP and PUN are the explanatory variables for different time period t

177 B_0 = intercept

178 β_1 , β_2 and β_3 = the structural coefficients to be estimated

179 U_{2t} = error term

180 From a priori expectation

181 B_1 and $\beta_3 > 0$, $\beta_2 < 0$

182 The actual output of coconut is expected to move in the same direction as total number of palms
 183 planted and price per unit nut. This is so because the more the ~~total~~ number of palms planted by the
 184 coconut growers, the more chances of having greater yield. Also, the higher the price per unit nut of
 185 the produce the more coconut growers are motivated to cultivate more palms and thus there will be
 186 an increase in actual output. On the other hand, the higher the number of diseased palms, the lower
 187 the actual output of coconut since deficiencies of coconut palms would result in reduction of actual
 188 output.

189 **Model 2.1: Logarithm of Economic Cost (LNEC)**

190 Using the logarithms of all the variables in equation (2), we obtain the econometric equation to be
 191 estimated as:

$$\text{Log EC}_t = \alpha_0 + \alpha_1 \log \text{EAYDP}_t + \alpha_2 \log \text{PUN}_t + \alpha_3 \log \text{RDPTNP}_t + U_{1t} \quad - \quad - \quad - \quad (5)$$

Equation (5) is a “log linear” or “double log” specification. Note that using a double log specification enables us to directly obtain the elasticity of the dependent variable (EC) with respect to each of the explanatory variables in the model. Therefore, α_1 , α_2 , and α_3 are constant elasticities which tell us the degree of responsiveness of economic cost to changes in the explanatory variables. Hence, α_1 gives the elasticity of EAYDP with respect to EC, α_2 gives the elasticity of PUN with respect to EC and α_3 gives the elasticity of RDPTNP with respect to EC. The ordinary least squares (OLS) regression method can be used to estimate the model. Recall that the Gauss-Markov theorem demonstrates that, provided certain fairly general assumptions hold, using the OLS regression technique to estimate the parameters of a single-equation yields coefficient estimates that are best linear unbiased (BLUE) and hence they possess the desirable properties of unbiasedness, consistency and efficiency [8].

Model 2.2: Logarithm of Actual Output (LNAO)

Using the logarithms of the variables in equation (4), we obtain the econometric equation to be estimated as:

$$\text{Log AO}_t = \beta_0 + \beta_1 \log \text{TNP}_t + \beta_2 \log \text{NDP}_t + \beta_3 \log \text{PUN}_t + U_{2t} \quad - \quad - \quad (6)$$

The coefficients β_1 , β_2 and β_3 are the elasticities of actual output (AO) of coconut with respect to total number of palms (TNP), number of diseased palms (NDP) and price per unit nut (PUN) respectively.

Equations (2), (3), (5) and (6) are estimated using collected data and the OLS regression technique.

In summary, the following models are estimated:

Model 1.1

$$\text{EC} = f(\text{EAYDP}, \text{PUN}, \text{RDPTNP})$$

Model 1.2

$$\text{AO} = f(\text{TNP}, \text{NDP}, \text{PUN})$$

215 **Model 2.1**

216 $\text{Log EC}_t = \alpha_0 + \alpha_1 \log \text{EAYDP}_t + \alpha_2 \log \text{PUN}_t + \alpha_3 \log \text{RDPTNP}_t + U_{1t}$

217 **Model 2.2**

218 $\text{Log AO}_t = \beta_0 + \beta_1 \log \text{TNP}_t + \beta_2 \log \text{NDP}_t + \beta_3 \log \text{PUN}_t + U_{2t}$

219

220 **Table 5: Descriptive Statistics of Variables for Secondary Data**

STATS	TNP	NDP	EO	AO	EAYDP	PUN	EC	RDPTNP
Mean	444.7500	258.3500	71160.00	29824.00	41336.00	64.00000	3177840.	50.95536
Median	394.5000	99.50000	63120.00	11200.00	15920.00	60.00000	1038400.	48.20072
Maximum	895.0000	849.0000	143200.0	131680.0	135840.0	100.0000	13584000	97.92899
Minimum	95.00000	0.000000	15200.00	1920.000	0.000000	30.00000	0.000000	0.000000
Std. Dev.	358.5735	293.4648	57371.76	38228.54	46954.37	24.79389	4228937.	33.95921
Skewness	0.142591	0.927782	0.142591	1.467583	0.927782	0.122440	1.333308	0.094478
Kurtosis	1.190262	2.363809	1.190262	3.870198	2.363809	1.829705	3.365969	1.627379
Jarque-Bera	2.797066	3.206550	2.797066	7.810371	3.206550	1.191297	6.037315	1.599829
Probability	0.246959	0.201236	0.246959	0.020137	0.201236	0.551205	0.048867	0.449367
Sum	8895.000	5167.000	1423200.	596480.0	826720.0	1280.000	63556800	1019.107
Sum Sq.								
Dev.	2442924.	1636311.	6.25E+10	2.78E+10	4.19E+10	11680.00	3.40E+14	21911.33
Observations	20	20	20	20	20	20	20	20

221

222 *Source: Author's computation using Eviews 7*

223 **Table 6: Model 1.1: Economic Cost (EC) Analysis**

Variable	Coefficient	t-statistic
C	-2029361	-3.217411
EAYDP	86.50755	12.84347
PUN	39103.04	2.415098
RDPTNP	-17098.68	-1.138677
R ²	0.962210	
$\bar{R}^2$	0.955125	
f-statistic	135.7986	
Durbin Watson Statistic	1.928020	

224

225 The result is very good with R² value of 0.962210 and R-bar squared of 0.955125. It is clear that we
226 are able to explain over 96% of the systematic variations in the dependent variables, Economic Cost
227 (EC) by the three independent variables (Expected Annual Yield of Diseased Palms (EAYDP), Price
228 per Unit Nut (PUN), and Ratio of Diseased Palms to Total Number of Palms (RDPTNP).

Overall significance of the model is impressive with F – statistic value of 135.7956 significant at the 10% level. This implies that a linear relationship exists between the dependent and independent variables taken together. Thus, the hypothesis of a linear relationship between economic cost and the regressors cannot be rejected. The Durbin – Watson statistic value of 1.92802 suggests the absence of autocorrelation. Furthermore, the estimated coefficients of EAYDP and PUN are correctly signed and are significant at 10% and 5% respectively. However, RDPTNP coefficient is incorrectly signed and is insignificant (not significantly different from zero).

On average, a unit rise in EAYDP and PUN would increase EC by approximately 86.51 and 39103.04 units respectively. This shows that EAYDP and PUN are significant determinants of economic cost of coconut production.

Table 7: Model 1.2: Actual Output (AO) Analysis

Variable	Coefficient	t-statistic
C	6.51E-11	1.656360
TNP	160.0000	3.15E+15
NDP	-160.0000	-2.26E+15
PUN	-6.75E-13	-1.213842
R^2	1.000000	
$\bar{R}^2$	1.000000	
f-statistic	5.42E+30	
Durbin Watson Statistic	1.960328	

The estimated results are very robust with R^2 and $\bar{R}^2$ value of 1.000. This implies that 100% of the systematic variations in the regressand (AO) are explained by the regressors (TNP, NDP, PUN). The F – statistic value of 5.42E + 30 is highly significant at 10% level, easily passing the significance test at the 10% confidence level. Consequently, the hypothesis of a linear relationship between the regressand and the regressors cannot be rejected (is validated). Thus, the estimated model shows a reliable goodness -of - fit. The Durbin - Watson’s value of 1.96 suggest the absence of autocorrelation in the estimated model. The estimated coefficients meet a priori expectations and are highly significant at 10% level except for PUN. It shows that on the average, a

unit rise in TNP and NDP will increase and decrease AO by 160 and 160 units respectively. We, therefore, conclude that TNP and NDP are significant determinants of AO of coconuts in the area.

Table 8: Model 2.1: Logarithm of Economic Cost (LNEC) Analysis

Variable	Coefficient	t-statistic
C	-0.971360	-0.470167
LNEAYDP	1.216246	11.46380
LNPUN	0.551719	0.904972
LNRDPTNP	0.169682	0.462761

The estimated results of LNEC model further substantiate that of the EC model. It shows that the elasticity of EC to EAYDP equals 1.21. This means that EC is elastic relative to EAYDP. Furthermore, PUN elasticity of EC is 0.55 indicating that EC is inelastic relative to PUN.

Table 9: Model 2.2: Logarithm of Actual Output (LNAO) Analysis

Variable	Coefficient	t-statistic
C	16.91687	3.606117
LNTNP	0.386767	0.798953
LNNDP	0.134842	0.396362
PUN	-2.499259	-2.769229

The LNAO model reveals that the coefficients of the explanatory variables are not significant except for PUN; which is significant at 5% level. Its value of – 2.499259 shows the PUN elasticity of AO. In absolute terms, this value is greater than unity, indicating that AO is elastic with respect to price per unit nut (PUN).

Conclusions

The research demonstrates the econometric analysis of the economic cost of lethal yellowing disease on coconut yield in Nigerian Institute for Oil Palm Research (NIFOR).

264 It is evident from the research that coconut production level in the area under study falls below its
265 potential output. This shortfall in production is consequent on the fact that ~~lethal yellowing disease~~
266 ~~incidence~~ had a devastating impact on coconut yield.

267 Having considered the economic cost of ~~lethal yellowing disease~~ on coconut yield, it is, therefore,
268 recommended that ~~campaign on how to prevent and control the incidence of LYD should be~~
269 ~~conducted regularly by extension workers.~~

270 In the light of the foregoing, if followed, there will be a reduction in the incidence if not ~~totally~~
271 ~~eradicated~~, of ~~lethal yellowing disease~~ in the zone.

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